Growth Variation and Early Selection of *Betula Platyphylla* in Natural Stands

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Abstract The stem analysis of *Betula platyphylla* in natural forest at the Maoershan Forest Experimental Station of Northeast Forestry University, showed that the growth variation of the trees, including height and diameter breast height, decreases with the increase of the age. There is the turning point for the growth variation of the tree from acute change to relative stability when the trees are in eighteen years old. There are significant differences among the height, diameter and volume growth of the trees at that time. Therefore, the optimal age for early selection of this species in natural stands is eighteen years old (18 a). Diameter is used as main index for early selection and height growth as auxiliary one.

Key words: *Betula platyphylla*, Early selection, Growth variation

Introduction

Early selection is an important part for forest tree improvement. Tree quality and production can be improved through selection. In recent years, we have paid more attention to early selection and prediction. Early selection is an important part for forest tree improvement. The genetic quality and production of forest tree can be improved by selection. In order to shorten breeding period of forest species and provide excellent individual, genetically improved progenies and clone for forest production by early selection, we have paid more attention to this field in recent years: Many species have been studied, which include *Pinus koraiensis*, *Larix olgensis*, *Picea koraiensis* and some broad-leaf trees etc. The purpose of this study is to know better the growth condition, genetic variation and wood quality of *Betula platyphylla*, thus providing more information for the further tree improvement of this species.

Materials and Methods

Materials

The materials were from 21 dominant trees in natural stands at the Maoershan Forest Experimental Station of Northeast Forest University. Stem analysis were made by cutting the trees in 2 m as differentiation section. And then the tree height (H), diameter breast height (D) and volume (V) at age 3, 6, 9, 45 were calculated.

Methods

Firstly, coefficients of variation (CV) of above characteristics were calculated. CV/3 was used to estimate the decreasing rate of CV. The purpose is to study the change trends of those characteristics and their stable age.

Secondly, correlation coefficients of juvenile-mature characteristics also were calculated, which include, r_{HH}, r_{DD}, r_{VV}, r_{HV}, r_{D^2V}, r_{DV}.

Thirdly, linear regression equation was established using the characteristics ratio between early age and late age as independent variable, and correlation coefficient as dependent variable. The fitted value of correlation coefficient was calculated at different age. Selection efficiency was calculated and optimum age for early selection was decided .

Finally, Regression equation was fitted using main selection index and assistant selection index at optimum selection age. Volume at 45a was predicted. Optimum prediction model was selected.

Results and Analysis

Individual growth variation pattern

Growth variation pattern of individual was studied by using variation coefficients and its decreasing ratio of the characteristic at different age (Fig. 1 and Fig. 2). It indicates in Table 1 that the variation coefficients of D and V gradually decrease with the increase of the indi-

vidual age. Their fluctuation is greater in early age, and slower after the trees in 18a, and tends to be stability after that.

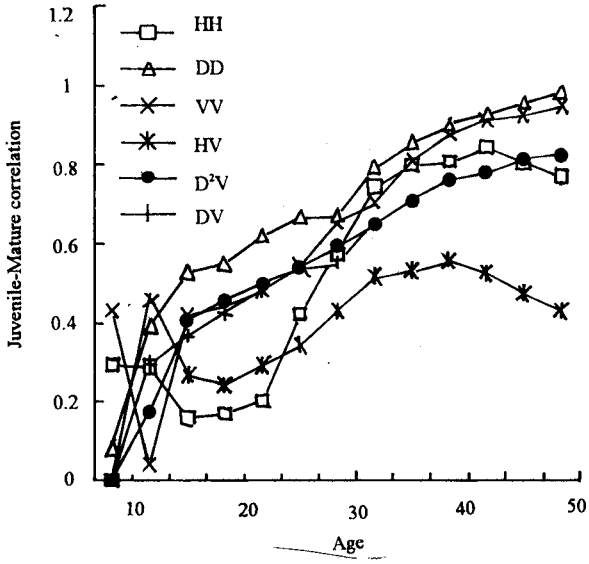

Fig.1 **The coefficient of variation**

Therefore, it is the turning point for the growth variation of the tree from fast change to relative stability when the trees are in 18a, in which volume variation is the greatest among all characteristics and height variation is the least one. That means the height growth of individuals is more stable than the other characteristics. The similar result has been reported in *Pinus sylvestris* var. *mongolica* [1].

Juvenile-mature correlation of growth characteristics

Since there is long-term growth period for tree species, it is difficult for us to wait and make analysis when they are in rotation age. All trees analyzed in this time were in 45a as mature age. Several correlation coefficients of juvenile-Mature characteristics (r_{HH}, r_{DD}, r_{VV}, r_{HV}, r_{D^2V}, r_{DV}) were calculated. The results were illustrated in Table 1 and Fig. 3.

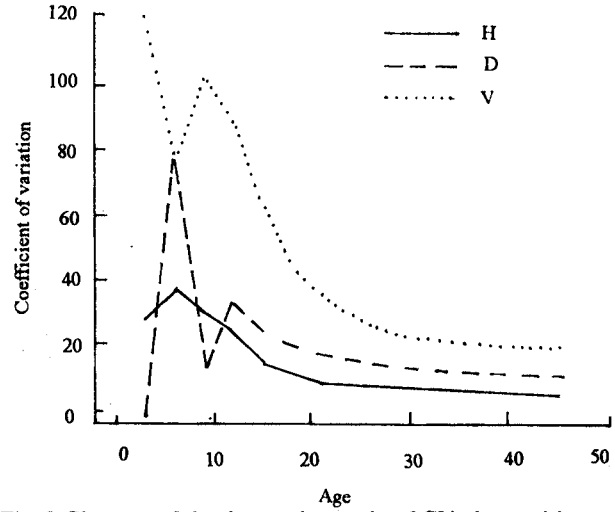

Fig. 2 Changes of the decreasing ratio of CV along with age

In Table 1 and Fig.3, it can be seen that all the correlation coefficients among characteristics increase with the tree age, and go faster at young age. The older the tree age is, the slower correlation coefficients increase. The curve become more and more gently after the trees over 27a. There were significant differences among the correlation of D-D, as well as correlation of D^2-V at the trees in 18a. Almost coefficients reached significant leave at 21a. So, it is reliable for *Betula platyphylla* to do early selection after the tree in 18a. Moreover, because both of r_{D^2V} and r_{DV} are higher than r_{HV}, it is more effective to use diameter as main index for selection than to the height characteristics.

Table 1. Juvenile-mature correlation coefficient of *Betula platyphylla*

Age	HH	DD	VV	HV	D^2V	DV
3	0.2909		0.0807	0.4319*		
6	0.2860	0.3915	0.0395	0.4571*	0.1751	0.2932
9	0.1587	0.5261*	0.4162	0.2644	0.4030	0.3662
12	0.1679	0.5472**	0.4367*	0.2410	0.4557*	0.4221*
15	0.1983	0.6193**	0.4764*	0.2910	0.4971*	0.4817*
18	0.4171*	0.6643**	0.5416*	0.3404	0.5385**	0.5354**
21	0.5748**	0.6705**	0.6504**	0.4301*	0.5920**	0.5491**
24	0.7418**	0.7896**	0.7015**	0.5141*	0.6475**	0.6540**
27	0.7969**	0.8560**	0.8080**	0.5311*	0.7100**	0.7160**
30	0.8064**	0.9007**	0.8754**	0.5572*	0.7599**	0.7629**
33	0.8420**	0.9277**	0.9141**	0.5256*	0.7786**	0.7809**
36	0.8048**	0.9549**	0.9246**	0.4734*	0.8117**	0.8136**
39	0.7707**	0.9789**	0.9476**	0.4301*	0.8237**	0.8276**

Note: * stand for 0.05 significant level, ** stand for 0.01 significant level

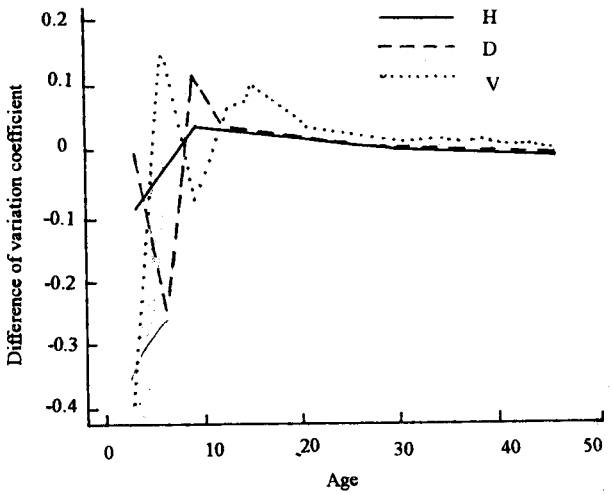

Fig. 3 Changes juvenile-mature correlation along with age

Early selection efficiency

On the basis of study on growth variation of the individuals and its correlation of the characteristics, linear regression equation were calculated, using metural logarithm of characteristics ratio between early and late age (45a) as independent variable, and sample correlation coefficients as dependent variable (Table 2). Fitted value of different correlation coefficient was estimated using these equations. Using H, D and D^2 as index, the selection efficiency of mature volume was calculated.(Table 3). Early selection efficiency was calculated as followers $E=r\ (T_m/T_i)$, where E is early selection effective, T_m is cutting age (45a+2a), T_i is early selection age, r is fitted value of correlation coefficient among juvenile-mature growth characteristics.

Table 2. Regression equation on juvenile-mature correlation coefficient of growth characteristics

Correlation coefficient	Regression equation	R-squared
H (early)-H (late)	Y=0.836184+0.2945961LAR	0.6649**
D (early)- D (late)	Y=1.00468+0.3239051LAR	0.9629**
V (early)-V (late)	Y=0.979679+0.3879461LAR	0.9396**
H (early)-V (late)	Y=0.490257+0.064866 LAR	0.2176
D (early)-V (late)	Y=0.858883+0.3109021LAR	0.9651**
D^2 (early)-V (late)	Y=0.872478+0.329919LAR	0.9827**

Note LAR stands for natural logarithm of ratio of juvenile age and mature age

Diagram of curves was drawn using selection efficiency at different age (Fig. 4). The result shows that selection efficiency by using different selection index is different. For tree height, its selection efficiency decreases with age. Selection efficiency of diameter and square of diameter is little at young age and increased with age after that time. It reaches to the maximum value when the trees are from 9a to 18a, and then decrease with the age. Because there is no great difference between the height growth in 18a and volume growth in 45a and clearly variation exists between diameter growth and volume growth. So it is better to consider the diameter as main index for early selection of this species in natural stands. Also, it can be sure that the optimal age of early selection of *Betula platyphylla* is 18a.

It can be seen that there exists significant difference for the regression equations between height growth of the trees in 18a and volume growth of the trees in 45a. And the same results have been archived for diameter and square of diameter.

Table 3. Selection efficiency of H, D and of D^2

Age	H	D (d)	Square of D
3	4.725	0.355	-0.315
6	2.700	1.740	1.560
9	1.930	1.795	1.705
12	1.509	1.680	1.635
15	1.257	1.551	1.439
18	1.078	1.435	1.393
21	0.945	1.333	1.301
24	0.842	1.243	1.247
27	0.762	1.167	1.173
30	0.696	1.100	1.109
33	0.641	1.039	1.050
36	0.595	0.988	0.999
39	0.555	0.939	0.952
42	0.521	0.897	0.911
45	0.490	0.859	0.872

Thus, the height and diameter growth of the trees in 18a can be used to predict the volume growth of the trees in 45a in natural stand.

Regression prediction

Regression analysis was made for volume characteristics at the trees in 45a using tree height and square of D. *F* test was done for these regression equations. The results were listed in Table 4.

Table 4. Volume (V) prediction of the trees in 45 years old using H and D of 18 years old

Regression characters	Regression equations	*F* value
H18-v45	v45=0.142327+0.0200777 H18	2.57
D18-v45	v45=0.243613+0.00104023 $D^2$18	7.76
H18$D^2$18-v45	v45=0.108418+0.015229 H18+0.000955 $D^2$18	4.99

Conclusion

The growth variation of *Betula platyphylla* in natural stands is greater before the trees in 18a than after that, and increases with the tree age. The same trend can be seen in the CV fluctuation.

There is no juvenile-mature correlation relationship among the characteristics of the trees in young age, but it increases more quickly along with the tree age, especially the trees less 18a.

Through analysis of variation, juvenile-mature correlation, and calculation of the early selection efficiency of growth characteristics of *Betula platyphlla*, it is considered that the diameter breast height can be used as main index for early selection of this period, and height growth as auxiliaries one. The optimum selection age for *Betula platyphlla* is 18 years old.

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